INDIAN TEA ASSOCIATION

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1939

1940

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SCIENTIFIC DEPARTMENT

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The health of the staff during the year has been normal.

Mr. Harrison and Dr. Wight were on home leave during the year.

Mr. N. M. Macgregor joined the Department in September as Senior Advisory Officer.

The various buildings have been maintained in a satisfactory condition.

A new bungalow, necessitated by the appointment of Mr. Macgregor, is in course of erection.

The District Advisory Officers, Messrs. F. S. Mitchell, E. J. Winter, and Dr. E. K. Woodford have toured in their respective districts, and in addition the Officers from Tocklai have visited the undernoted districts :—

Assam	Bishnauth, Dhunsiri, Doom Dooma, Golaghat, Mangaldai, Nazira, North Lakhimpore, Nowgong, Panitola, Sonari and Tingri.
Surma Valley	Balisera, Chargola-Longai, Chutla Bheel, Happy Valley, Luskerpore, Mid-Sylhet, and North Cachar.
Darjeeling.	

Dooars — Chalsa, Dalgaon, Dam Dim, Jainti-Sankos, Nagrakata, and Oodlabari.

Terai.

Correspondence during the year has amounted to :—

Letters received	...	6,880
Letters despatched	...	6,760

The number of samples received during the year were as follows :—

Chemical Branch	...	940
Entomological Branch	...	104
Mycological Branch	...	2,330
Bacteriological Branch	...	212
Botanical Branch	...	24

Three Circulars and 4 Memoranda have been published during the year—

Circulars :

Eel worms on Tea Seedlings.
War-time Manuring.
Long Horned Beetle Borer in Tea Chest Wood.

Memoranda :

Nitrogen Supply to Tea.
The Tea Plant in Industry : Some General Principles.
Growth Promoting Substances.
Manuring of Tea in War-time.

The Third Annual Conference was held on 16th, 17th and 18th February.

Owing to the outbreak of war the Lecture Courses usually held towards the end of the year were cancelled.

There were 186 visitors to the Station during the year.

The area under tea is 89.86 acres.

The field experiments at Tocklai and Tulsipara have been continued in accordance with the programme.

Experiments on Estates—Last year the hope was expressed that the number of experiments carried out on tea estates might be increased and I am glad to be able to say that we have had an excellent response in that we have been able to lay down 28 new experiments.

Owing to the outbreak of war towards the end of the year and to the general uncertainty it was decided that experiments that were not then in being had better not be commenced. It now has been found possible to make arrangements for some new experiments to be initiated. Also it has been found possible to continue the experiments that were started before the outbreak of war. We hope that all these experiments will continue without any break in their continuity.

The work of the year has followed very closely the published programme.

Pruning—Over a number of years at Tocklai, experiments have been carried on to determine the effect of different methods of annual pruning on the quality and the quantity of the tea made. It has been shown that the effect of cutting across when pruning, without the removal of any shoots, has not given as good results either in crop or quality as pruning so as to remove banjhi (dormant) shoots and weak branches (Tocklai pruning). It was however necessary to find out what would be the effect of the more severe cleaning out, such as is commonly done in Upper Assam. The Tocklai system was compared with the system in which bushes were cleaned out so that the remaining shoots were spaced no closer than 4" apart. The result gave a significant difference neither in crop nor quality. A still more severe system of pruning known as stick-pruning was compared with the Tocklai pruning. During the second flush (spring growth) better quality and a much greater crop was obtained from the less severe Tocklai pruning. At no time did the stick-pruning give better teas than the Tocklai system. After the second flush there was no significant difference between the quality of the teas. These

experiments show that whilst a light cleaning out is necessary, any more severe pruning than the removal of banjhi shoots and very weak branches may result in a considerable loss of crop with no gain in quality.

Plucking—An experiment to find out to what extent variation in the fineness of plucking affects crop and quality has been carried out at Tocklai during three different years. The results of the experiments are summarised as follows :—

The superfine plucking, which consisted of all shoots of one leaf and a bud and two leaves and a bud, obtained the highest valuations. They were however only slightly greater than those of the fine plucking which consisted of a small number of large one and a bud and mainly of two leaves and a bud and very few three leaves and a bud. Over the whole of 1939 season, the average difference was 1.5 pies which is not significant.

The superfine and fine plucking was preferred to the coarse (free) plucking, which consisted of all shoots grown in a week except those of one leaf and a bud. The coarse plucking consisted of about 30% three leaves and a bud, and the difference in valuation on the average was in the neighbourhood of one anna. The difference between coarse and fine plucking varies to some extent with the year and the state of the market. For instance,

(1)	1934 rains teas	difference = 0 a. 6 p.
(2)	1935 teas to end of July	difference = 1 a. 2 p.
(3)	1939 whole season	difference = 1 a. 1 p.

The very coarse plucking consisting of nothing finer than three and a bud was on all occasions valued considerably lower than the superfine plucked teas. For instance,

(1)	1934 rains teas	difference = 1 a. 1 p.
(2)	1935 teas to end of July	difference = 1 a. 3 p.
(3)	1939 whole season	difference = 2 a. 1 p.

In 1939, on the first occasion of manufacture, 19th May, the leaf from all types of plucking was small and stunted and good teas were made and well valued in Calcutta. There was very little difference, whatever the style of plucking. So soon however as the shoots began to grow freely the coarser plucked teas received lower valuations.

The superfine plucked teas were often referred to as having more quality. The liquor from the coarse plucked teas was often reported as having a common character.

Manuring—Comparisons of teas from bushes manured with organic and inorganic manures have been again repeated at Tocklai and the results obtained confirm previous experiments on the subject. No evidence whatsoever has been obtained to indicate loss of quality due to the use of inorganic manures in preference to organic manures. Valuations of the teas vary in accordance with the crop except that sulphate of ammonia gives a better tea than might be expected from the crop. It is not proposed to repeat these experiments, since they have already been done several times and the evidence obtained is sufficiently conclusive.

Factory—Further work has been carried out in connection with the infection of leaf withered on bamboo-hessian chungs. Reference has been made to this being brought about by borers. It has now been ascertained that the insect responsible is a species of termite which spends its life-history inside split bamboo 'kamies'. The termite is in no direct connection with the earth and there is very little indication of its presence. It is only seen when the 'kamies' are broken. The result of a relatively small infection of the leaf by this means may impart a coarse character to the finished tea with loss of briskness and deterioration in colour of the infused leaf and liquor. A chemical investigation has shown that the extent of the tannin oxidation is much greater than under normal conditions and that such leaf needs to be fermented for a shorter time, for instance if the time of fermentation is

reduced from 3 hours to 2 hours a considerable improvement in the tea results.

Some form of ceiling cloth spread under the infested bamboo 'kamies' should be used to prevent the leaf on the lower withering chung becoming infected. It would, however, be better to avoid the use of bamboos and to use wire instead, but the wire must be kept clean otherwise it will impart infection to the leaf.

Passing withered leaf through a green leaf sifter prior to rolling separates an extraordinary assortment of material, consisting of broken damaged buds which frequently become sour, hessian fibre, termites, a variety of insects, particles of sand, brick, lime and iron rust. As much as 1 lb. of such foreign matter has been extracted from the withered leaf going to a single roller. The use of a machine as described by Mr. Allan of the Dooars at the Third Annual Conference for separating such miscellaneous foreign matter seems fully justified. It may not be possible to avoid insects, but sand, brick, and lime originate in defective floors, and iron rust from insufficient painting of the iron structure.

The following three points dealing with cleanliness in a factory are worthy of attention :—

(*i*) The necessity of clean withering houses. These should be cleaned after each day's manufacture, removing all old leaf not only from the chungs but also from the alleyways and floors after a bulk has been collected.

(*ii*) Frequent attention to the less obvious part of a roller are important as for instance the roller doors. These need to be kept thoroughly clean, and this involves more than just washing. In some cases as much as ¼ lb. of material has been collected from a roller door that has not been properly cleaned for a week.

(*iii*) It is also important to draw attention to the fact that metal trolleys do not keep clean automatically but need to be frequently washed during the time of manufacture.

Tea Fermentation—A considerable amount of work has been done relating to the mechanism of the fermentation process in tea as a result of which much insight has been gained into the nature of the chemical changes involved, and we are now in a position of understanding the main reactions of fermentation sufficiently well, we hope, to make practical application of this knowledge.

The results of this work which are of a very technical nature have been published in scientific form in a series of papers in the Biochemical Journal. It would serve no useful purpose for such papers to be published by the Indian Tea Association. The following is a brief summary of some of the more practical points :—

(*i*) The rate of fermentation varies at different times of the year for the same bush.

(*ii*) The rate of fermentation varies with different bushes of the same jat.

(*iii*) Rate of fermentation varies with different jats. Some jats, *e.g.*, Singlo, have a very slow rate of fermentation compared with other jats such as China or Betjan.

In all our manufacturing experiments carried out during the year the jat factor has proved to be the greatest. Wide variations in manufacturing conditions have resulted in little or no change in valuation, but differences in jat may make as much difference in valuation of the tea as 2*d*. per lb.

During withering the enzyme complex controlling the rate of fermentation loses activity and consequently a slower rate of fermentation might be expected from well withered leaf.

With the increase of withering however, the permeability of the leaf tissue is increased and this seems to offset the loss in enzyme activity, so that the fermentation time remains very much the same with different degrees of wither. At very high withers a faster rate of fermentation is just noticeable.

Differences in plucking might also be expected to result in differences in the time of fermentation, since coarse plucked leaf contains less tannin than the fine plucked. The leaf from the fine plucking under the same withering conditions becomes more permeable, however, and again the time of fermentation remains much the same for the coarse and fine plucking.

A considerable amount of work extending now over several years has been done to ascertain the effect of temperature on fermentation. The results so far obtained can best be summarised as follows :—Lower temperatures increase quality, briskness, and tint of colour, while higher temperatures give increased strength and depth of colour of liquor.

One characteristic calls for particular mention :—the depth of the colour of the tea liquor is noticeably increased with the higher temperature but the tint of the colour also undergoes a change. This can be best appreciated if the tea has milk added to it. It will then be noticed that at the lower temperatures of fermentation, except in the case of very slow, fermenting jats, there is an improved tint, the tea having the rosy pink colour which seems to be so much appreciated.

How the different teas are valued depends largely upon the tasters, some of whom will prefer the greater briskness, quality, and tint of colour obtained at the lower temperatures whilst others will value more particularly on the strength and depth of colour, and will in general prefer teas fermented at somewhat higher temperature.

It is, however, important to notice that whilst strength of liquor increases as the fermentation temperature rises from 60°F. to 80°F., yet at 90°F. it is less than at 80°F.

An important point that has come out of this investigation is that the variation in temperature has a comparatively small effect upon the rate of oxygen consumption during fermentation. Some factor other than the oxidation of tannin must be accountable for the differences found between teas fermented at different temperatures. Tannin has the property possessed by a number of other chemical substances of condensing, that is to say, of the molecules combining together, and it is the extent of condensation of the tannin molecule that is thought to be responsible for many of the tea characteristics. A study of the condensation of pure tea tannin is one of the outstanding problems of tea and it was hoped that this would be a problem which would be investigated in the scheme for tea investigation that is being carried on in England.

Flavour—The work on flavour and aroma has been of a theoretical and preliminary nature, and as might be expected no practical results have as yet been obtained.

Moulds—The investigation in regard to mould in finished tea is being continued. It is of interest to note that final firing (gaping) the tea for as long as 15 minutes at 180°F. leaves still a large mould infection in the tea. This work is being continued.

Tea Plant—Various forms of the tea plant have been recognised and arranged in a series which shows imperceptible gradations from a light-leafed Assam to a China type. It has been shown that certain growth characters of the tea plant are associated with a general tendency towards a certain position in the series and that some qualities which become evident in the manufactured leaf are related to the position the particular plant occupies in the series.

The fertility of the tea bush depends upon the source of pollen and varies greatly with pollen from different sources. A collection of nine clones seems to be necessary to give a fair chance (19 : 1) for an average seed crop. The possibilities arising from a knowledge of interfertility of the

material is well illustrated by the instance in which the selection of the source of pollen has resulted in a 36% set of seed on a particular seed-bearer as compared with the more average 2% by random pollenation.

In making crosses it needs to be borne in mind that it is the characteristic of the progeny that must be considered and by which the usefulness of the crosses must be judged.

Immature fruits fall from the trees from the time of fertilisation to the time of dehiscence of mature seed. There are two periods of fruitfall, one soon after fertilisation and the other in the middle of the season. This loss of fruit is being further investigated.

The percentage set of seed is the same for all descriptions of flowers.

The plants obtained from seed originating at different positions on the stem of the seed-bearer could not be distinguished from each other.

The percentage germination of floater seeds is less than that of sinkers but there is no difference in the size of the plants raised. It seems therefore that floaters of a good jat of seed might be marketed profitably both to sellers and buyers.

A great deal of work has been done in the vegetative propagation of bushes. Cuttings from different bushes root very differently and experiments have shown that the successful rooting varies greatly with the type of cutting. A selection of bushes that give cuttings which root easily has been made.

The technique in bud grafting has shown great improvement, for the success obtained by budding on to good stock is now 79% and it should be possible to improve upon this result. The success however varies with the stock used.

The study of hair distribution on the leaf has been continued as time has permitted. The density of hairs on the leaf determines the tippy appearance of the finished tea,

a high density giving good tip. The following conclusions have now been reached :—

(1) 'Nitrogenous manuring reduces the density of the hair on the leaf. At Tocklai the use of 60 lbs. of nitrogen per acre as a manure gave so slight an alteration in the density of the hair as to be unlikely to have any practical difference except perhaps in the case of strains which are deficient and near to the critical limit of sufficiency for tip-making. It is of interest to note that tasters were unable to notice any significant falling off in the quality of tea resulting from bushes at Tocklai that had received nitrogenous manure at the rate of 60 lbs. of nitrogen per acre compared with those from unmanured areas. With heavier applications of nitrogen significant differences did occur in quality. It is not suggested that these applications are critical for anywhere else than Tocklai, but they indicate that excessive nitrogen application can cause both a reduction in quality and tip of tea.

(2) 'The hair density varies with the jat and seems to be a heritable character.

(3) 'The hair density has been correlated with relative humidity, a period of high relative humidity being followed by reduced hair density and *vice versa*.

(4) 'There is evidence that the hair density on successively formed leaves shows a periodic fluctuation.

The accumulated data obtained from 3000 manufactures of leaf from individual bushes shows that there is a close and significant correlation between briskness and quality. This correlation has also been shown in the tea manufactured from the mixed population of individual plots.

Black Rot—A continuation of the field experiments on estates has continued to show the inefficiency of cold weather

spraying for the control of Black Rot, but control of this disease and Thread Blight has been to some extent effected by clean pruning.

Thread Blight—The experiments are being continued.

Red Spider—Work is also being continued for the control of Red Spider.

Young Tea—Two experiments dealing with young tea have yielded interesting new information.

(1) On the tea planted in October, 1935, 60 lbs. nitrogen gave a much better effect than 20 lbs. nitrogen, for the first time, in 1939, the fourth year after planting. On these plots, the effect of potash continues to be great. The effect of phosphoric acid is practically negligible, though there is a slight good effect from phosphoric acid when applied with a high nitrogen dressing. It is interesting to note that the light-leafed jat makes much better use both of nitrogen and of potash than the dark-leafed jat. We cannot say that this applies to all light-leafed or to all dark-leafed jats: but it is interesting to note that jat can make so much difference to the ability of a bush to make use of manure.

(2) On the tea planted in October 1936, very good effects from 60 lbs. nitrogen per acre appeared in 1939, only the third year after planting. Effects from only 20 lbs. might have been as good, but we think that this tea, having been more lightly pruned, was in condition to use more nitrogen in its third year than the severely pruned tea planted in 1935. This tea was planted in 1936 both with and without sau trees at 45′ × 45′ triangular. It is interesting to observe that where no nitrogen was used, the sau trees in 1939 produced a not significant increase in crop; definite gains from the sau trees are expected very soon on these unmanured plots. The plots with shade trees and nitrogen gave significantly less crop than the similar plots with nitrogen but without shade. How long this bad effect of shade trees on well manured soil will persist, remains to be seen.

Shade Experiments—It has to be admitted that our belief in the beneficial effect of shade is founded on general experience, unconfirmed by experiment. An attempt is being made to remedy this and the following experiments have been laid down, and in some cases preliminary yields have been recorded.

(i) On commercial gardens

Five experiments with and without shade combined with manurial trials.

Four experiments with three varieties of shade combined with manurial trials.

Two experiments dealing only with varieties of shade.

One experiment dealing with the distance apart of shade trees.

(ii) At Tocklai

One experiment started in 1936 deals with varieties of tea with and without shade and with and without nitrogen.

A new experiment planted in 1939 compares seven varieties of shade trees, and no shade, with and without potash, and with and without phosphate.

Nitrogenous manures—Among nitrogenous manures, sulphate of amonia continues to do better than concentrated organic manures and much better than bulky organic manures, both at Tocklai and in a number of experiments on commercial estates. At Tocklai 21 plots which have had 120 lbs. inorganic nitrogen annually for ten years, with no organic matter except their own prunings, averaged 19 mds. tea per acre in 1939, and soil and bushes appear to be in splendid condition. The data is discussed in Appendix I.

Potash and Phosphate—The experiments to ascertain the value of potash and phosphate carried out on tea estates have been continued, and new experiments have been started.

The 24 experiments started in 1935, 1936 and 1937 show very similar results in 1939 to those obtained in 1938.

In most cases the increase produced by applications of nitrogen is significant. With few exceptions applications of potash and phosphate gave increases in crop far below that required for significance. From the number of apparent gains from potash and phosphate it seems likely that the addition of these substances to the soil does help the bush to produce more leaf, but the increases are so small that applications of these manures will not generally pay commercially.

Twenty new experiments have been started to include more types of soil in the investigation.

The results obtained during 1939 are given in Appendix 2.

On the big manuring plots at Tulsipara the same result has been registered, namely a significant increase from nitrogen, but only indications of increases from potash and phosphate.

At Tocklai we meet with an exception only in regard to potash on young tea, the increase from which is still highly significant in 1939.

Cultivation—There is a new experiment at Tocklai comparing the effects of 2, 4, 6 and 8 light hoes, each with different cold weather treatments, and with different dressings of sulphate of ammonia. The land was clean, at the start of the experiment. In the first year, there was no effect at all from increased depth of cultivation, and relatively small effects from increased frequency of cultivation: the maximum difference being one maund per acre in favour of plots getting 8 light hoes compared with those getting only two. On the older plots, we found similar small effects in early years. Results from greater frequency of cultivation are expected to increase as the under-cultivated plots become more thickly infested with weeds. The good effect from an extra 30 lbs. nitrogen per acre was the same whether cultivation was very little or very intensive, being 1.2 mds. tea per acre.

The older plots, both at Tocklai and at Tulsipara, gave results similar to those of previous years, indicating that suppression of weeds is the effective factor in cultivation.

It is regretted that it has not been found possible to extended these investigations to other types of soil, on commercial estates but it is hoped that this will be remedied when the Advispry Officers take up residence in their respective districts.

Plucking—The closer the plucking the greater the crop, though the appearance of the bushes indicates deterioration, and the gains from closer plucking decrease with time.

At Tocklai in the first year of treatment 1.4 mds. tea per acre was lost for every additional 2″ additional growth left: but in 1939 the fifth year, the difference is only 1 md.

At Tulsipara over a maund of tea was gained in 1932, the first year of good crop, but only half a maund in 1939, from plucking at 6″ instead of 8″ new growth.

Other Experiments—In addition to these experiments, the following subjects are under experimental investigation on commercial gardens :—

Composts
Autumn and Spring manuring
The value of sulphur
Potash for young tea.
Four levels of nitrogen on shaded tea
Sulphur and Lime
The manuring of tea seed trees
Hard and Light plucking
The two-stage top prune
The light and heavy medium prune
The pruning of young tea
The biennial and triennial prune

APPENDIX I.

Experiments with Humus Composts, Cattle Manure and Similar Materials

1. *Halem. Coarse sandy soil on North Bank, Assam. Seventh year of similar treatment.*

Manure per acre.	Mds. tea per acre 1939	
	Total crop	Gain from manure.
Artificial mixture 340 lbs. 40 lbs. Nitrogen 20 lbs. Phosphoric acid 20 lbs. Potash	13·63	1·95
Cattle manure 200 mds. 85 lbs. Nitrogen 67 lbs. Phosphoric acid 72 lbs. Potash	12·75	1·07
No manure	11·68	...
Significant difference	0·46	0·46

Efficiency per unit of nitrogen.

Cattle manure shows about one quarter of the efficiency of the artificial per unit of nitrogen.

Efficiency for cost, at Halem.

Cattle manure gives 1·07 mds. for Rs. 8-2.

Artificial gives 1·95 mds. for Rs. 26 at War prices.

Increase crop from cattle manure costs Rs. 7-10 per md. of tea.

Increased crop from artificial costs Rs. 13-5 per md. of tea.

200 mds. is 7 $\frac{1}{7}$ tons, few gardens can apply cattle manure at Rs. 1-2-2 per ton.

At the present war prices of artificials, cattle manure, on its effect at Halem can be valued at just under Rs. 2 per ton, applied.

2. *Aenekhal. Bheel soil. Cachar. No shade. Third year of similar treatment.*

	Means of 5 plots			Means of 15 plots
	No nitrogen	5 Tons humus compost	200 lbs. Sulphate of ammonia	
With 100 lbs. sulphate of potash per acre	9·59	10·25	9·64	9·83
No potash	8·81	9·02	8·38	8·74
Means of 10 plots	9·20	9·64	9·01	

Between means of 10 plots a difference of 0.88 is required for significance.

Between means of 15 plots a difference of 0.71 is required for significance.

No significant effect appears from either sulphate of ammonia or humus compost. Apparently this soil can use no more nitrogen than it has by nature.

The effect of the sulphate of potash is highly significant. The humus compost contains about as much total potash as the 100 lbs. sulphate of potash; but the humus potash is ineffective.

3. *Luckymugger. Bheel soil. Cachar. Irregular shade. Third year of similar treatment.*

Manure per acre	Mds. tea per acre
No manure...	9·62
5 tons humus compost	9·76
200 lbs. Sulphate of ammonia	9·92
200 lbs. Sulphate of ammonia 150 ,, Superphosphate 60 ,, Sulphate of potash }	10·58
Significant difference	1·60

No manure shows any significant effect.

Humus compost is as ineffective as sulphate of ammonia.

4. *Champarai. Sylhet. Teela soil heavily shaded by Sau trees. The tea was unpruned in 1939 and yielded very heavily. Fourth year of similar treatment.*

Manure per acre	Mds. tea per acre
300 lbs. Sulphate of ammonia (60 lbs. nitrogen) ...	32·1
8 tons Humus compost ,, ,, ,, ...	28·1
No manure	26·9
Significant difference	2·3

It is most remarkable that the sulphate of ammonia is able to increase even the enormous yield of the unmanured plots.

5. *Leesh River. Coarse Sandy soil in Western Dooars. No shade. Third year of similar treatment.*

Manure per acre	Mds. tea per acre 1939	
	Total crop	Gain from manure
No manure	8·35	...
5 tons Humus compost (40 lbs. nitrogen)	8·98	0·63
10 „ „ „ (80 „ „)	9·71	1·36
200 lbs. Sulphate of ammonia (40 lbs. N.)	11·55	3·20
400 „ „ „ „ (80 „ „)	13·09	4·74
Significant difference ...	0·91	0·91

The effect of 10 tons humus compost is now statistically significant, but is much less than the effect of half as much nitrogen as sulphate of ammonia.

6. *Gandrapara. Rich loam in the Dooars. No shade now: but had been heavily shaded in the past. Third year of similar treatment.*

Manure per acre	mds. tea per acre 1939	
	Total crop	Gain from manure
300 lbs sulphate of ammonia (61 lbs. nitrogen)	15·72	3·00
5 tons humus compost (71 „ „)	14·05	1·33
760 lbs. dry cut jungle 240 lbs. cowdung } (83 „ „)	13·81	1·09
No manure	12·72	...
Significant difference	0·91	0·91

Sulphate of ammonia is very significantly the best. The fermented compost and unfermented materials do not differ significantly.

Costs per acre 1939		Cost per maund of tea produced
Sulphate of ammonia	Rs. 20/- ...	Rs. 6-11
Humus compost	,, 13/12 ...	,, 10- 5
Unfermented materials	,, 12/13 ...	,, 11-12

7. *Allynugger. Very old tea on typical red sandy loam plateau soil of Sylhet. No shade. Third year of similar treatment.*

Manure per acre	mds. tea per acre, 1939		
	Total crop	Gain from manure	Cost per acre.
Artificial mixture	6·99	2·26	Rs. 39–13–0
Indore compost (fermented)	5·59	0·86	Rs. 15– 9–8
Dacca compost (fermented)	5·77	1·11	Rs. 20–13–8
Materials for Dacca compost (unfermented)	6·34	1·68	Rs. 12– 0–9
Acme animal meal	7·50	2·74	Rs. 78–11–0
No manure	4·73	...	...
Significant difference	0·66	0·66	

All manures except the artificial mixture supplied about 85 lbs. nitrogen; the artificials have been a little wet and averaged 77 lbs. nitrogen.

The best value is obtained from the unfermented dry jungle (7 tons) with 20 lbs. nicifos.

8. *Borbhetta. No shade. Third year of similar treatment.*

All manures gave close to 80 lbs. nitrogen per acre except the Dacca Compost and the materials for Dacca compost.

For these two sets of plots dried cut jungle, cattle manure, and nicifos were at hand ready bulked.

The correct quantities were weighed out and applied to one plot, and then the same quantities to form the base of a compost heap. This operation was repeated 7 times, till 7 plots had been manured, and a compost heap of 7 layers prepared. The compost heap was then watered, fenced, and given the orthodox waterings and turnings. Analysis of the materials showed that 90 lbs. nitrogen per acre were applied to the plots receiving the unfermented "Dacca" materials.

When the compost was ready, after fermentation for 3 months, it was weighed and one-seventh of the total weight applied to each of the seven plots intended for this treatment. So much had been lost in fermentation that these plots received 70 lbs. nitrogen.

Indore compost was prepared from rice straw, cattle manure, urine-earth, and wood ashes. Part of the same bulks were kept in a shed and applied at the same time as the Indore compost, and in the same proportions, to apply the same quantity of nitrogen per acre. In this case then we compare only the difference in efficiency per unit of nitrogen due to fermentation.

Adco compost was prepared from rice-straw and calcium cyanamide.

Manure per acre	mds. tea per acre 1939	
	Total crop	Gain from manure
Sulphate of ammonia	9·06	3·81
Cattle manure	7·03	1·78
Fermented composts ... Indore ...	6·83	1·58
Fermented composts ... Dacca ...	6·77	1·52
Fermented composts ... Adco ...	6·64	1·39
Unfermented materials applied direct to soil ... Indore...	7·11	1·86
Unfermented materials applied direct to soil ... Dacca ...	7·64	2·39
No manure	5·25	...
Significant difference	0·56	0·56

There is no significant difference between the effects of any of the four fermented composts including cattle manure.

The unfermented Indore materials are fully as efficient before fermentation as afterwards.

The unfermented Dacca materials are significantly more effective before fermentation than after fermentation.

Sulphate of ammonia is highly significantly better than any other manure, having about 2½ times the efficiency of the average fermented compost supplying the same quantity of nitrogen.

9. *Borbhetta. Second year of similar treatment.*

Application of cut-jungle direct to the soil, with and without readily available nitrogenous artificial.

The jungle used is the blue-flowered shrub *Eupatorium odoratum* commonly called Giant Ageratum because its flower resembles that of the common tea-garden annual weed. This is cut and tied into bundles about 1 foot in diameter and 5 to 6 ft. long. The tying into bundles prevents the fall of the valuable leaf during transport. The bundles are left to dry in the sun to reduce their weight and then carried into the tea, opened, and spread. Application is at two rates (3 and 6 tons of dried material per acre) both dressings being applied alone, and also together with 30 lbs. and 60 lbs. available nitrogen per acre. In 1938 the available nitrogen was as calcium cyanamide. In 1939 sulphate of ammonia was used.

In 1939 the following results were obtained in mds. tea per acre.

Manure per acre	Means of 4 plots			Means of 12 plots
	Tons 0	Eupatorium 3	per acre 6	
lbs. sulphate of 0 ...	6·39	6·94	7·95	7·09
ammonia 150 ...	7·13	8·61	9·12	8·29
per acre 300 ...	7·95	8·82	9·94	8·90
means of 12 plots	7·16	8·12	9·00	

Between means of 12 plots a difference of 0.53 mds. is required for significance. The three tons of Eupatorium have just about the same value as 150 lbs. sulphate of ammonia, and 6 tons about the same value as 300 lbs. sulphate of ammonia.

There is no significant interaction. Within experimental error jungle and artificial used together, give the same increase in crop as the sum of the increases of the two used separately. The green jungle is satisfactory manure when used alone, and there is no necessity to use any form of available nitrogen together with it.

We can therefore give one ton of the sun-dried jungle cuttings about same value as 50 lbs. sulphate of ammonia.

At present War prices of sulphate of ammonia, Rs. 190 per ton or perhaps Rs. 210 including freight and application, 50 lbs. are worth Rs. 4-10. This is equivalent to about Rs. 2-9 per ton for the freshly cut undried material. It should be possible on most gardens to manure some area with cut jungle at lower prices than these.

APPENDIX II.

Phosphate and Potash Manuring

The results of experiments with Nitrogen, Potash and Phosphate on 25 commercial gardens are tabulated below. They tend to confirm our belief that on most tea soils neither Potash nor Phosphate affect crop appreciably.

Nitrogen

In 24 out of the 25 experiments nitrogen alone has produced an increase in crop, in 13 experiments this increase is statistically significant by the "z" test.

Phosphate

Although Phosphate has increased the crop in 15 out of 25 experiments such increase is not significant in one single case.

Potash

Potash has led to an increase in crop in 16 out of the 25 experiments and in two of the experiments, the increase has proved statistically significant.

The Potash and Phosphate interaction

Curiously enough the interaction between Potash and Phosphate though estimated with only half the accuracy of the main effects has proved significant in 4 out of the 25 experiments, once positive and 3 times negative.

Table I shows the comparative yields of the 5 separately treated plots.

Table II shows the mean yields from the Potash and Phosphate plots and also the Potash and Phosphate interaction.

TABLE 1

Garden	No manure	N	NP	NK	NPK	Sig. Diff. "t" test
Cachar Plateau and Teelah Soils						
Silcoorie	3·6	4·1	5·1	4·8	4·7	1·3
Durgakhuna ...	5·68	7·70	8·61	8·24	7·12	1·14
Serispore	17·38	17·21	18·45	17·81	17·24	1·54
Khoreel	9·62	12·97	12·75	14·07	13·80	1·21
Cachar Clay flats						
Ruttonpore ...	2·14	3·66	4·68	4·57	6·32	2·08
Chandypore ...	4·91	7·20	6·29	6·95	7·30	1·41
Cachar Old Bheels						
Lallamukh ...	7·95	9·77	10·10	10·54	10·61	1·17
Lallacherra ...	13·51	15·18	15·70	15·92	15·51	1·66
Rich Heavy Flats of Humus character Cachar						
Singalla	15·10	16·31	19·10	17·49	18·17	2·50
Derby 40	10·09	10·51	10·98	10·09	10·64	...
80	11·01	9·93	10·25	10·14	11·06	...
Rich Bheel Soils—Cachar						
Poloi (60 N) ...	11·52	12·60	12·17	12·73	11·71	2·66
Luckynugger ...	9·62	9·92	10·79	10·11	10·58	1·61
Rich Red Loam on Flat						
Burnie Braes ...	12·51	16·57	15·69	15·45	17·66	2·06
Red Bank Soils						
Dooars	...	...	...	...	...	...
Moortee	8·11	11·12	11·69	11·42	10·68	·63
Matelli	10·19	12·18	14·18	13·88	13·33	1·16

TABLE I—(*Contd.*)

Garden	Nil	N	NP	NK	NPK	Sig. diff. "t" test
Grey Sandy loams						
Rydak	13·77	15·04	15·14	15·33	15·18	·72
Kartick	8·99	9·81	10·03	10·37	9·90	1·01
Coarse Sand						
Baradighi	11·26	13·68	15·20	14·10	14·33	1·74
Sandy Soils						
N. 5 N. Gogra ...	2·95	3·43	3·44	4·06	3·72	·98
7 Bindukuri ...	6·90	8·71	8·48	8·34	8·90	·78
4 N. Gogra... ...	9·47	10·28	9 36	10·80	11·08	2·18
Red Bank						
No. 3 O. Gogra ...	5·30	6·45	6·51	6·01	6·80	·72
No. 4 O. Gogra	5·80	6·99	6·72	6·57	6·94	2·09
Seajuli	8·25	11·90	11·70	12·27	12·15	·59

The figures underlined are significantly higher than the unmanured plots by the "t" test.

N = nitrogen

P = phosphate

K = potash

TABLE II

	+ P	− P	+ K	− K	+ PK	− PK	S D.		Yield increased by P	K	PK
Silcoorie	4·90	4·45	4·75	4·60	4·40	4·95	·92		+	+	
Durgakhuna	7·87	7·97	7·68	8·16	7·41	8·43	·81				
Serispore	17·85	17·51	17·53	17·83	17·23	18·13	1·09		+		
Khoreel	13·28	13·52	13·94	12·86	13·39	13·41	·86			+	
Ruttonpore	5·50	4·12	5·45	4·17	4·99	4·63	1·47		+	+	+
Chandipore	6·80	7·08	7·13	6·75	7·25	6·62	1·00			+	+
Lallamukh	10·36	10·16	10·58	9·94	10·19	10·32	·83		+	+	
Lallacherra	15·61	15·55	15·72	15·44	15·35	15·81	1·17		+	+	
Singalla	18 64	16·90	17·83	17·71	17·24	18·30	1·76		+	+	
Derby 1	10·81	10·30	10·37	10·75	10·58	10·54	Nil		+		+
2	10·66	10·04	10·60	10·09	10·50	10·20	Nil		+	+	+
Poloi	11·94	12·67	12·22	12·39	12·16	12·45	1·88				
Luckynugger	10·69	10·02	10·35	10·36	10·25	10·45	Nil		+		
Barnia Braes	16·68	16 01	16·56	16·13	17·12	15·57	1·16		+	+	+
Moortee	11·19	11·27	11·05	11·41	10·96	1·56	·45				
Matelli	13·76	13·03	13·61	13 18	12·76	14·03	·82		+	+	
Rydak	15·16	15·19	15·26	15 09	15·11	15·24	·51			+	
Kartick	9·97	10·09	10·14	9·92	9·86	10·20	·72			+	
Baradighi	14·77	13·89	14 22	14·44	14·01	14·65	1·23		+		
No. 5 N. Gogra	3·58	3·75	3·89	3·44	3·58	3·75	·69			+	
7 Bindukuri	8 69	8·53	8·62	8·60	8·81	8·41	·55		+	+	+
4 N. Gogra	10·22	10·54	10·94	9·82	10·68	10·08	1·54			+	+
No. 3 O. Gogra	6·66	6·23	6·41	6·48	6·63	6·26	·51		+		+
No 4 O. Gogra	6·83	6·78	6·76	6·86	6·97	6·65	1·48		+		+
Seajuli	11·93	12·09	12·21	11·80	12·03	11·99	·42			+	+

(1). *The significant results from Potash Manuring on Seajuli and Khoreel*

The need for any mineral fertilizer may be expected to increase from year to year. The yearly results of the two experiments since they were started are considered below.

Seajuli

	Mean with Potash	Mean without Potash	Difference
1936	12·89	13·03	–0·14
1937	13·80	13·29	·51
1938	12·38	12·40	0·02
1939	12·21	11·80	0·41

Difference required for significance in 1939 is 0·42.

It will be seen that the result this year is just not significant the figures however, are close enough to warrant discussion.

Here there seems to be no indication that the need for Potash is increasing : in fact, a perusal of these figures makes it seem probable that this result though close on significance is still due to chance.

Khoreel

	With Potash	Without Potash	Difference
1937	9·84	10·20	–0·36
1938	12·10	11·75	0·35
1939	13·94	12·86	1·08

Difference required for significance is 0·86.

In this table we have exactly what we are looking for, that is, an indication that the need for Potash is increasing from year to year. If this is a true reflection of fact these experiments may have a different story to tell in years to come.

The soil on the Khoreel plots is not very dissimilar to the soils on the Experimental plots on Silcoorie, Serispore and Durgakhuna.

We must wait a year or two more when, if the effect is still significant, a careful study of the respective soils on these 4 gardens may bring to light some reason for this abnormal result. In the meanwhile we must treat the result as an exception to the rule.

(2). *The Significant results of the Potash and Phosphate interaction*

At Burnie Braes this interaction has proved significant and is positive. By this is meant that the tea has failed to make full use of the dressings of either Potash or Phosphate unless both were applied together.

This positive interaction needs little explanation and might well be anticipated from general principles, seeing that both fertilisers when applied separately gave indications of an increase.

On three gardens Durgakhuna, Moortee and Matelli, the interaction is significant but negative. On the two former gardens both Potash and Phosphate show indications of having decreased the crop and perhaps it is not surprising that this decrease is exaggerated when the two fertilisers are applied together.

The fourth experiment, that at Matelli is more difficult to explain for although both Potash and Phosphate show definite indications of increasing the crop when applied separately, together they are far less effective.

The value of these experiments to the Advisory branch at Tocklai can not be over estimated. The data obtained justify omitting Potash and Phosphate from manuring programmes, for,

even if either Potash or Phosphate does increase the crop such increase is not likely to be commercially profitable.

For how long this advice can be continued to be given is another question.

With every 10 mds. of leaf plucked 20 lbs. of Potash and 8 lbs. of Phosphoric acid are being removed from the soil and it may well be expected that a time will come when deficiency of these minerals in the soil will make itself apparent upon the tea.

For this reason, although the immediate purpose of these experiments has been served it is extremely important that they should be continued for many years to come.

Three other experiments may be quoted, two at Borbhetta and one at Tulsipara.

Borbhetta, on old tea.

The results of the Phosphate-Potash experiment on the 9 acre Tingamira block are shown in the following cross table, expressed as mds. of pucca tea produced in excess of the plot which received no Phosphate and no Potash.

		lbs. of Potash per acre.				
		0	15	30	60	Mean
lbs. of phosphoric acid per acre.	0	0	missing treatment	·35	·41	·25
	15	·18	1·03	·70	·71	·66
	30	·59	·76	1·03	·87	·81
	60	·65	·77	1·38	·75	·89
Mean		·35	·85	·87	·69	

Difference between these means required for significance = ·39.

The main effect of 15 or 30 lbs. of Potash and 15, 30 or 60 lbs. of Phosphate is therefore significant. But while dressings of Potash in excess of 15 lbs. show indications of being unnecessary, increased dressings of Phosphate above 15 lbs. show increases in yield. These increases beyond the 15 lbs. dressing are not significant.

There is however an obvious regression in crop with increased dressings of Phosphate (if we omit the K 15 plots on account of the missing treatment) the mean increase in yield becomes

Phosphate	0	15	30	60	lbs. per acre.
	.25	.53	.83	.93	mds.

The regression is just significant : the variance ratio being 4.12. The ratio required for significance is 3.97 for odds of 19 to 1 against the occurrence of this effect by chance.

(3). *Tulsipara Big Manuring Plots.*

	Manuring lbs. of N	P	K	1939 Yield	(*a*) Average 1932-35	(*b*) Average 1936-39	Increase (*b*−*a*)
(1)	0	0	0	10·72	10·41	11·18	·77
(2)	40	0	0	13·36	11·30	13·73	2·43
(3)	40	40	0	13·81	11·75	14·39	2·64
(4)	40	0	40	14·56	11·88	14·09	2·21
(5)	40	40	40	13·83	11·68	13·77	2·09
(6)	40	0	80	13·82	12·04	14·10	2·08
(7)	80	0	0	15·33	13·11	15·33	2·22
(8)	80	0	80	15·24	12·49	15·24	2·75
(9)	80	0	160	15·00	12·91	15·04	2·13

S.D. 1·04

The only significant difference in the 1939 yields that can be attributed to either Potash or Phosphate is the difference between series 2 and 4 which amounts to 1.20 mds. and must be attributed to the 40 lbs. of Potash given to series 4. No such increase is shown between series 3 and 5 both of which have 40 lbs. of Phosphate in addition to the 40 lbs. of nitrogen given to series 2 and 4. Nor is there any indication of an increase from the 80 or 160 lbs. of Potash given to series 8 and 9 over their check plots in series 7. Further inspection of the last column shows that if anything series 2 has tended to pick up on series 4 in latter years. The significant result in question must therefore be regarded with suspicion and as occurring possibly by chance.

(4). *An experiment at Borbhetta on young 4 year old tea*

This somewhat complicated experiment at Borbhetta is designed to examine the response of 2 jats of tea to nitrogen, Phosphate and Potash.

The most interesting result so far obtained is the highly significant increase brought about by potassic manures.

	lbs. of Potash per acre			
	0	20	60	
Light leafed Jat	1539	1823	2087	Significant difference at 19 to 1 chance = 130 lbs.
Dark leafed Jat	1328	1434	1597	
mean	1434	1629	1842	

The dressing of potash had a significant effect on reducing the red spider attack in 1938.

The increase in crop from Phosphate is small on either Jat and the main effect is not significant even at the 19 : 1 level of probability.

	P—0 lbs. per acre	P—20 lbs. per acre	P—60 lbs. per acre
Light leaf ...	1759	1840	1850
Dark leaf ...	1405	1465	1487
Mean	1582	1653	1669

Phosphate reduced the incidence of red spider infection in 1937 and 1938.

The greater response to Potash than to Phosphate is attributed to the youth of the tea and any further experiments dealing with Potash and Phosphate on commercial gardens should be confined to young tea until the need for Potash by the young growing plant has been definitely established over a considerable range of soils.

It may be mentioned that, in the case of all three fertilizers, the light leaved jat has been able to make more use of the manure than the dark leaved jat in this experiment.